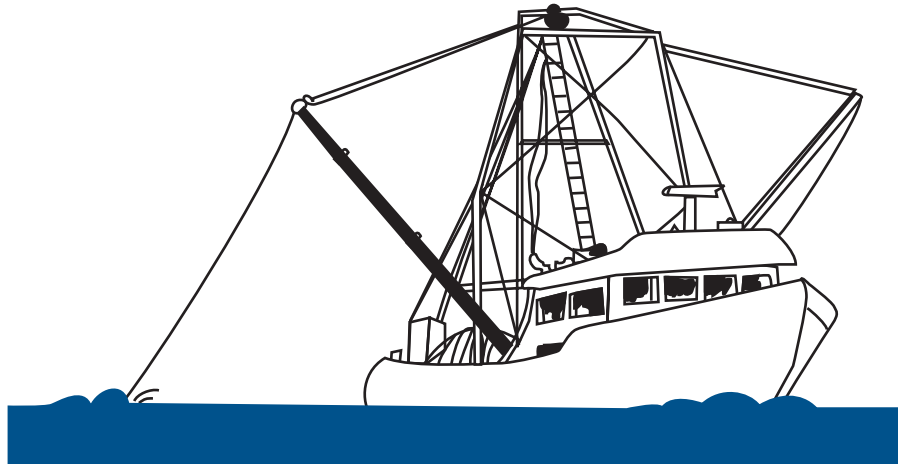


U. S. Department
of Transportation

United States
Coast Guard

*Commercial Fishing Industry
Vessel Advisory Committee*

A Best Practices Guide to Vessel Stability



Guiding Fishermen Safely Into the Future

For information on how to obtain extra copies of this booklet, contact your Fishing Vessel Dockside Examiner through your local U. S. Coast Guard Marine Safety Office. To find the phone number of the nearest Marine Safety Office, call the Coast Guard's toll free number at 1-800-368-5647 for a customer service representative.



Dear Commercial Fishermen,

In the past, our primary focus has been on reducing the consequences of commercial fishing casualties by ensuring fishermen were carrying and were trained in the use of the appropriate survival equipment. However, fishing vessels continue to capsize or sink before crew members are able to access survival equipment and lives are being lost. These types of casualties must be prevented. To this end, the commercial fishing vessel safety program focus has shifted to concentrate on preventing these casualties from ever occurring.

It has long been the premise of the United States Coast Guard that a vessel is its own best lifeboat, and it is therefore logical that prevention be the primary focus for this program. The onset of the Coast Guard's Prevention Through People (PTP) program has been the impetus for many new and innovative ideas for educating the industry as well as our own Coast Guard personnel on prevention measures. This Best Practices Guide to Vessel Stability, jointly prepared by the U. S. Coast Guard and the Commercial Fishing Industry Vessel Advisory Committee (CFIVAC), offers fishermen an excellent introduction to stability and provides sound recommendations for avoiding stability impairing scenarios that are encountered during day to day operations.

Although this booklet is not intended to be a complete course of study in fishing vessel stability, fishing vessel crews must be familiar with the basic stability concepts contained in the following pages and understand the potential effects of different operating conditions. Prevention of these casualties requires knowledge and training. Please take some time to read this book, and **SURVIVE TO FISH ANOTHER DAY!**

Sincerely,

A handwritten signature in black ink, appearing to read "Robert C. North". The signature is stylized and fluid.

Robert C. North
Rear Admiral, U. S. Coast Guard

ACKNOWLEDGMENTS

The completion of this “Best Practices Guide to Vessel Stability” would not have been possible without the assistance and input of numerous people and organizations. Thanks go out to LT Thomas Miller (U.S. Coast Guard) for his authorship and coordination, the Commercial Fishing Industry Vessel Advisory Committee (CFIVAC) Subcommittee on Stability for their input and peer review, Transport Canada for providing examples of previous successful booklets, and the U. S. Coast Guard’s Naval Architecture Division for their technical support and review. Special thanks go to Ms. Jennifer Blain and Mr. Howard Bagley for the countless hours spent formatting pages, editing content, and recreating artwork. Without these efforts, this booklet would never have been completed. Thank you to all who contributed.

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SOME SUGGESTIONS FOR PRESERVING ADEQUATE STABILITY

The following measures are recommended by the United States Coast Guard, in conjunction with the Commercial Fishing Industry Vessel Advisory Committee (CFIVAC). You should consider this as preliminary guidance on matters influencing the safety of fishing vessels as specifically related to preserving vessel stability.

1. All doorways and other openings through which water can enter the hull or deckhouses should be closed in adverse weather and when not in use.
2. All closures devices should be maintained on board in good working condition.
3. Hatch covers and flush deck scuttles should be kept securely closed when not in use during fishing.
4. All deadlights should be maintained in good condition and securely closed in bad weather.
5. All fishing gear and other large weights should be stowed, prevented from shifting, and placed as low as possible.
6. Care should be taken to maintain pull from fishing gear in line with the vessel's longitudinal centerline, and to avoid maneuvering with trawls off the quarters or beams.
 - ◆ Trawls off of the quarters or beams generate tremendous overturning forces that can easily capsize a vessel.
7. The point of action of the weight is at the hoist block of the frame or point of suspension.
 - ◆ Haul back pull points should be shifted to lower points during trawl operations. This lessens the magnitude of potential overturning forces generated when the trawl moves off the longitudinal centerline of the vessel.

8. Gear for releasing the deck load on fishing vessels carrying catch on deck, e.g. herring, should be kept in good working order for immediate use when necessary.
9. Freeing ports in bulwarks should always be open while underway.
10. When the weather deck is prepared for the carriage of deck load by division with pound boards, there should be slots between them of adequate size to allow an easy flow of water to the freeing ports. i.e. good drainage.
11. Never carry fish in bulk without first being sure that the portable divisions in the fish hold are properly installed.
The cargo must not shift.
12. Minimize the number of partially filled tanks. **Free surface can severely impair your vessel's stability.**
13. Observe any instructions given regarding the filling of water ballast tanks. Remember that partially filled tanks can be dangerous. They generate free surface!
14. Closing devices provided for vents to fueled tanks etc. should be secured in bad weather.
15. Be alert to the dangers of following or quartering seas. These may cause heavy rolling and/or difficult steering. If excessive heeling or yawing occurs, reduce speed, alter course, or both.
16. Do not overload. Overloading increases draft and decreases reserve buoyancy which **decreases stability.**
17. Avoid icing conditions. Standing wire rigging will ice-up to a greater extent than struts or yards. If icing cannot be controlled, leave the area immediately.
18. Maintain at least 1 foot of freeboard (distance from the waterline to deck) at all times.

AN INTRODUCTION TO THE PRINCIPLES ASSOCIATED WITH VESSEL STABILITY, THE FACTORS INFLUENCING STABILITY, AND THE TERMINOLOGY USED

The term “stability” normally refers to the ability of a vessel to return to the upright position after being heeled by an external force. The following is a brief explanation of the influencing factors and terminology encountered when dealing with vessel stability.

Stability of a vessel is the responsibility of the vessel owner, operator, and crew. It must be considered as an encompassing effort which addresses the following:

1. Watertight Integrity
2. Vessel Subdivision
3. Vessel Loading
4. Intact Stability
5. Damage Control
6. Vessel Cleanliness
7. Crew Training
8. Prudent Seamanship

WATERTIGHT & WEATHERTIGHT INTEGRITY

Goal: To provide the vessel with a proven means to minimize the effects of flooding.

Definitions:

Watertight - If water enters a space due to damage, the water is not able to leak into neighboring spaces.

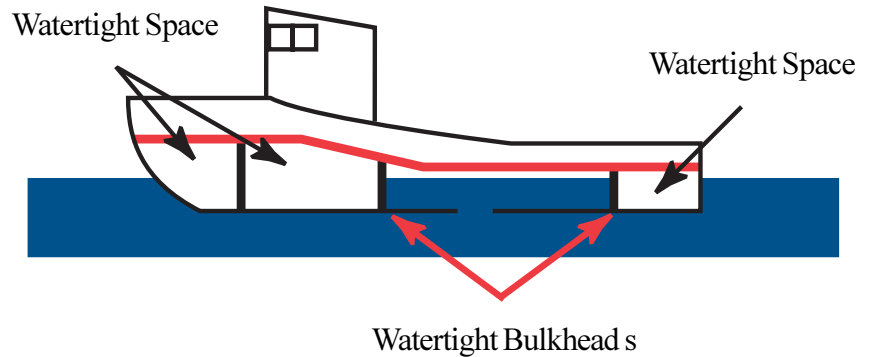
Watertight Bulkhead - A bulkhead that does not allow flooding waters to move between spaces.

Weathertight - When water and weather is prevented from entering a space, but the space is not watertight.

Bulkhead Deck - The uppermost deck to which watertight bulkheads extend, commonly the main deck.

Recommended Practices:

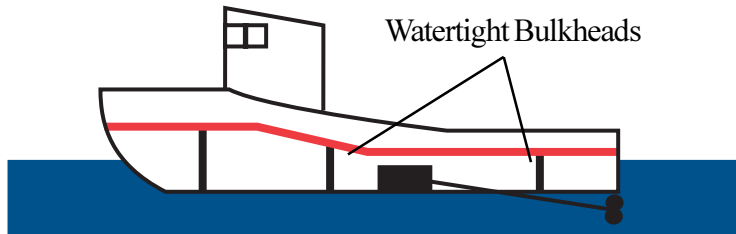
- ✓ Maintain watertight bulkheads watertight.
- ✓ Minimize number of penetrations.



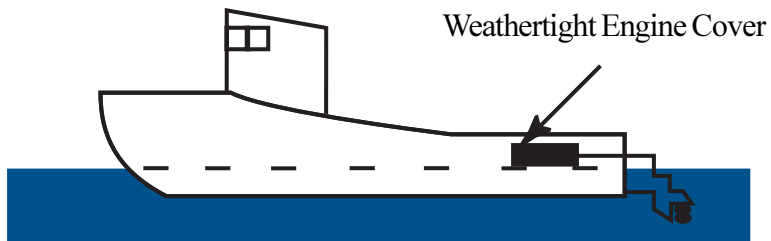
BULKHEAD DECK



WATERTIGHT & WEATHERTIGHT INTEGRITY



- ✓ Each machinery space containing propulsion, auxiliary power, fire or bilge pumping equipment should be enclosed by watertight bulkheads.
- ✓ Access to adjoining spaces below the bulkhead deck should be by normally closed quick acting watertight doors.
- ✓ Watertight doors should open outward from the machinery space.



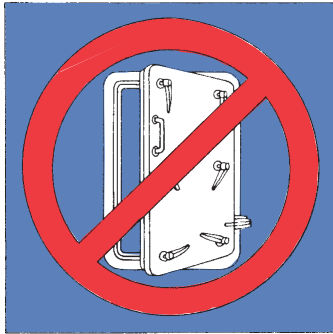
Recommended Practices (Continued):

- ✓ Discharge piping penetrating the hull should be fitted with check and positively closing valves.
- ✓ Inlet piping should be fitted with positive closing valves located as close as possible to the sea chests and shell plating.
- ✓ Deckhouse openings should be fitted with weathertight doors.
- ✓ Doors should be steel or equivalent material permanently attached to the bulkhead.
- ✓ Weathertight doors should open outward and be fitted with gasket seals and a minimum of two dogging devices in addition to hinges.
- ✓ All emergency doors should be quick acting.
- ✓ Propulsion Machinery Spaces above the bulkhead deck should be weathertight.

WATERTIGHT & WEATHERTIGHT INTEGRITY

Recommended Practices (Continued):

- ✓ Know the location of all watertight closures, and how to use them.
- ✓ Inspect all closures regularly, and report any defects to the master or operator immediately.



- ✓ Keep all watertight doors closed unless actually in use, especially before oncoming heavy weather.



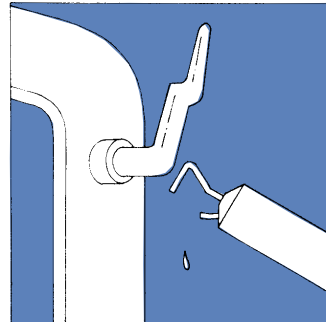
- ✓ Always keep portlights and deadlights closed and secured when at sea.



- ✓ Do not paint gaskets around weathertight closures. Maintain all gaskets in good condition.

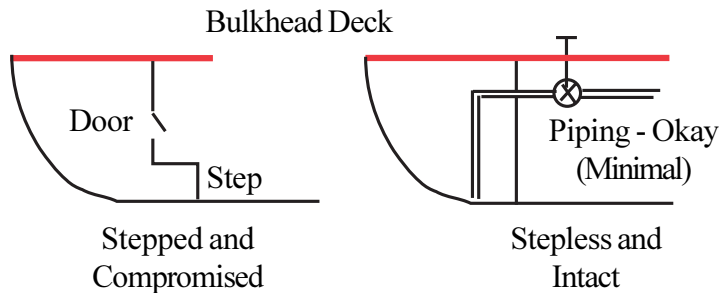
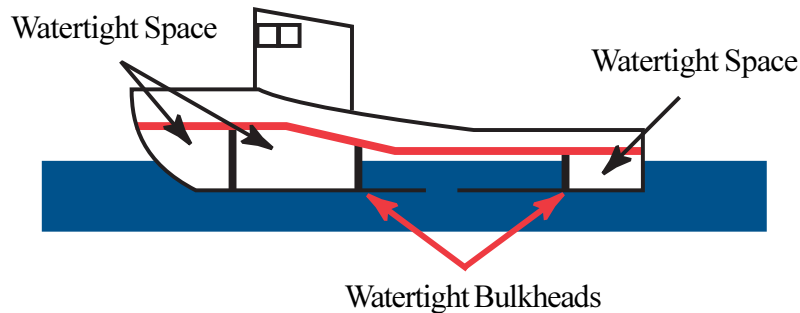
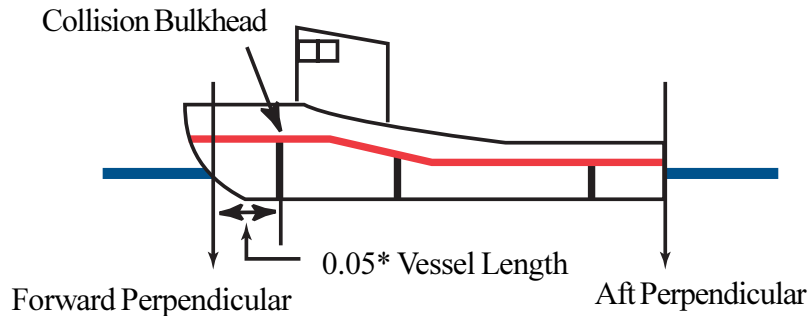


- ✓ Do not allow cargo or deck gear to block weathertight closures, or any other doorway.



- ✓ Inspect and grease all dogs regularly.

VESSEL SUBDIVISION



Goal: To provide multiple levels of protection to mitigate the affects of flooding.

Definitions:

Collision Bulkhead: Bulkhead designed to minimize spread of damage due to collisions or damage to the bow area. Must be stepless and intact.

Stepless and Intact: Strictly vertical bulkhead with minimal pipe penetration and NO doors.

Recommended Practices:

- ✓ Vessel be subdivided to include collision bulkhead, and watertight bulkheads as appropriate (maintain them watertight).
- ✓ Collision bulkhead be stepless & intact up to the bulkhead deck (no doors or scuttles).
- ✓ Only minimum pipe penetrations permitted.
- ✓ Penetrations shall include valves operable from aft of the collision bulkhead and above the bulkhead deck.
- ✓ Pipe penetrations shall be as far inboard & high as practicable.

VESSEL LOADING

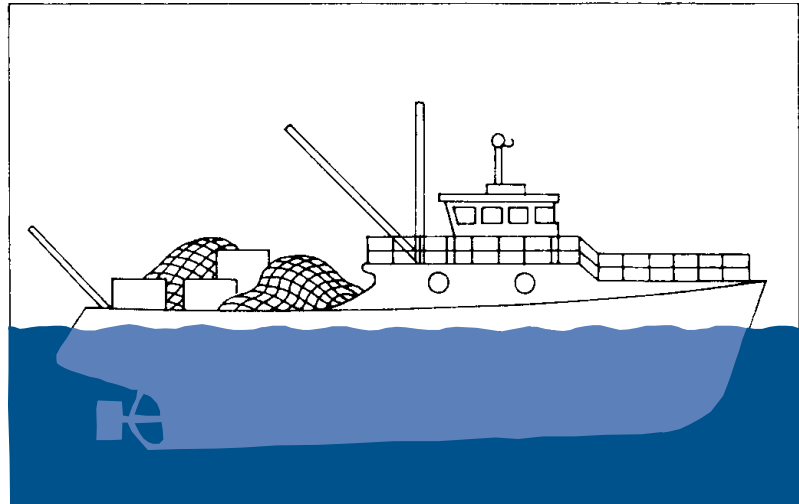
Goal: To load the vessel in the safest manner possible.

Recommended Practice:

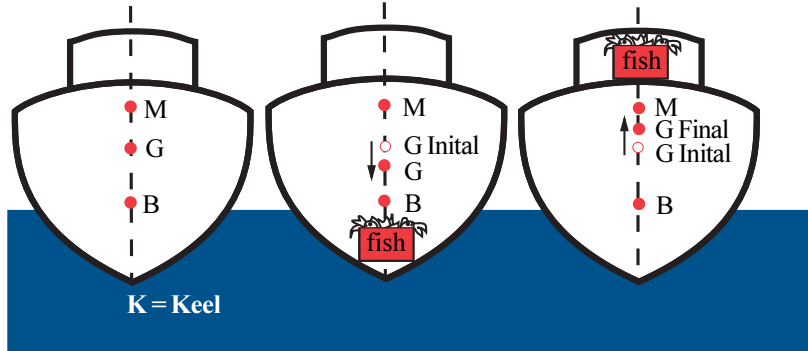
- ✓ Keep weight low.
- ✓ Avoid adding weight above the main deck.
- ✓ Secure gear and catch to prevent loads from shifting.
- ✓ Limit duration of side lifting operations.
- ✓ Minimize number of partially filled tanks.
- ✓ Do not overload.

Reminder:

An overloaded vessel does not have enough freeboard. **Overloading is a major cause of capsizing.**



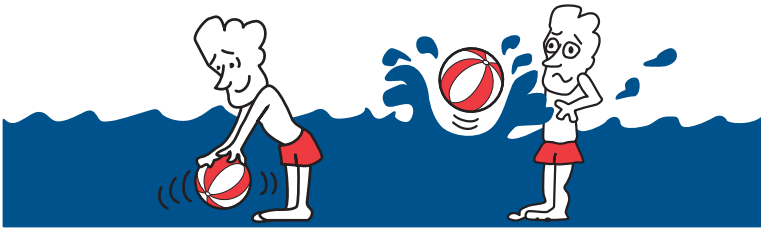
STABILITY DEFINITIONS



Goal: To familiarize you with common terms used when discussing stability.

CENTER OF GRAVITY

The point where the force of gravity acts on the vessel. Rises and falls when weights are moved, added, and/or removed (KG).



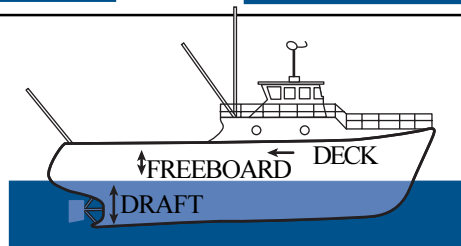
BUOYANCY

If a ball is pushed underwater, it will soon bob up again. This force that causes the ball to bob up is buoyancy.



CENTER OF BUOYANCY

The point through which the force of buoyancy acts vertically upwards (B).



FREEBOARD

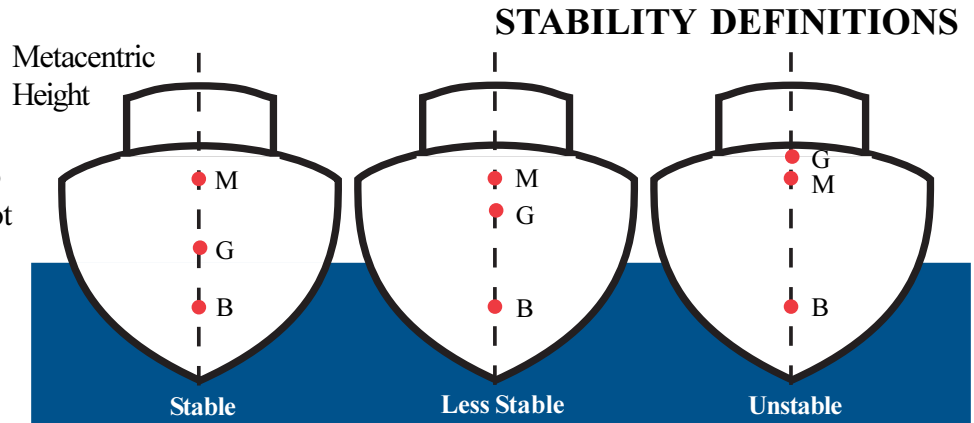
Distance between the waterline and the main deck.

METACENTER

Stability indicator that affects vessel's ability to remain upright. Based on vessel shape, will not move (M).

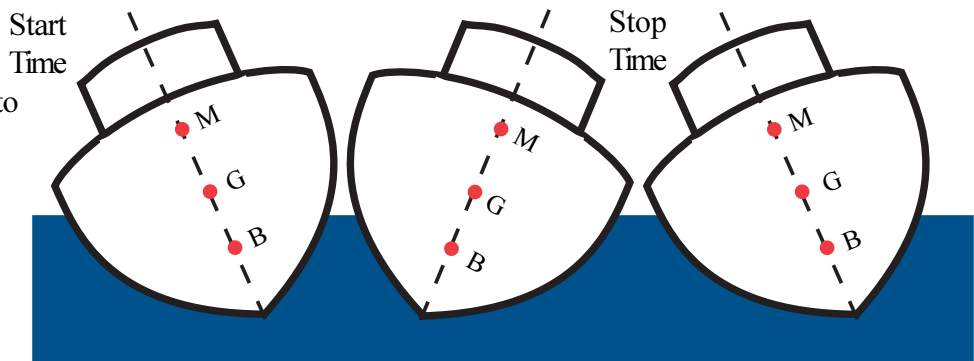
Metacentric Height

Distance between the center of gravity and the metacenter (GM).



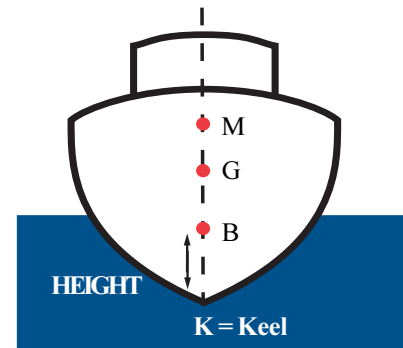
ROLL PERIOD

The time it takes for a vessel to roll from port to starboard back to port. Measured in seconds (T). If the roll period of your vessel is increasing, your vessel is becoming unstable.

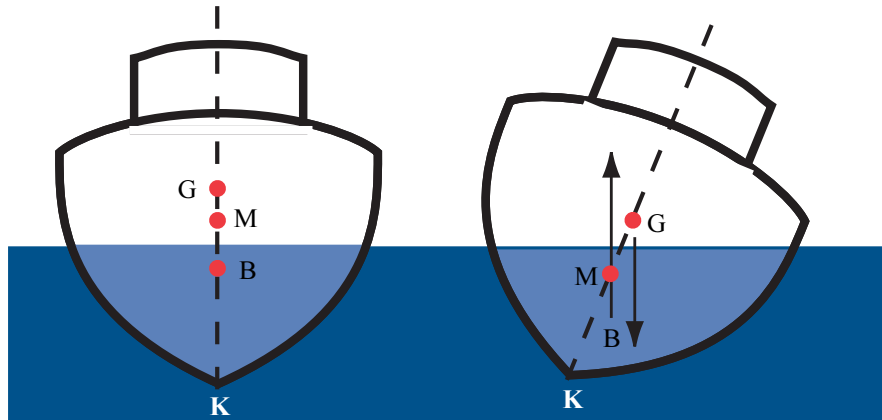


STABLE CONDITIONS

Your vessel is stable if, when inclined, it tends to return to the vertical position. For this to occur, the center of gravity must be below the meta-center.



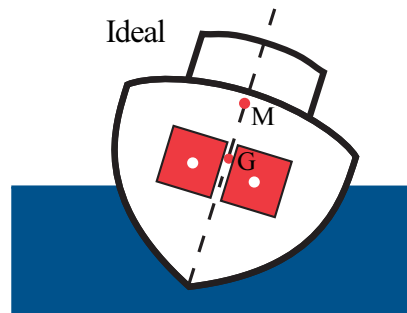
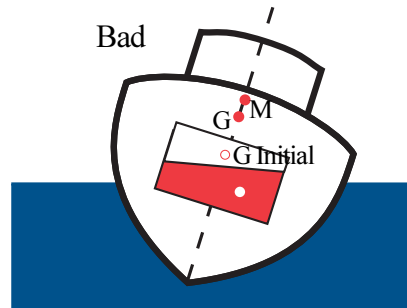
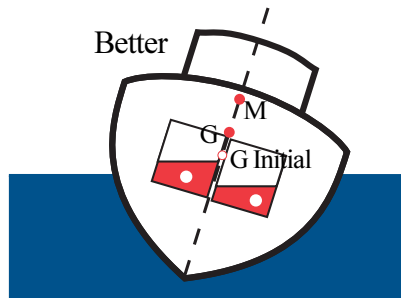
STABILITY DEFINITIONS



UNSTABLE CONDITIONS

If the center of gravity of a vessel moves above the metacenter due to weight additions or removals, your vessel is unstable.

When inclined, your vessel will fail to return upright and you will be in danger of capsizing.



FREE SURFACE EFFECT

When a vessel with half filled tanks is heeled, the liquid will shift to that side.

This shifts additional weight to the side the vessel is heeling to.

The center of gravity rises which reduces GM.

The vessel's ability to return to the upright position is then reduced.

Limit the effect of free surface by minimizing the width of tanks and the number of partially filled tanks.

INTACT STABILITY

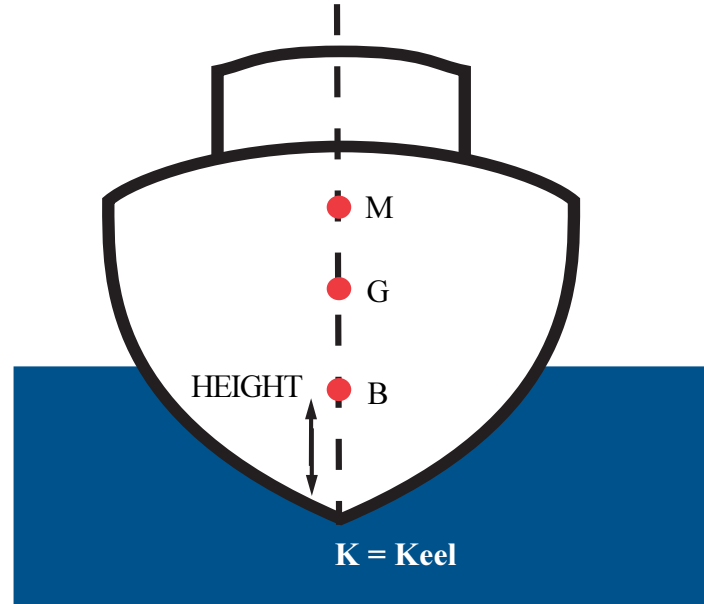
Goal: To maintain intact stability of your vessel at all times of operation.

Adequate Intact Stability

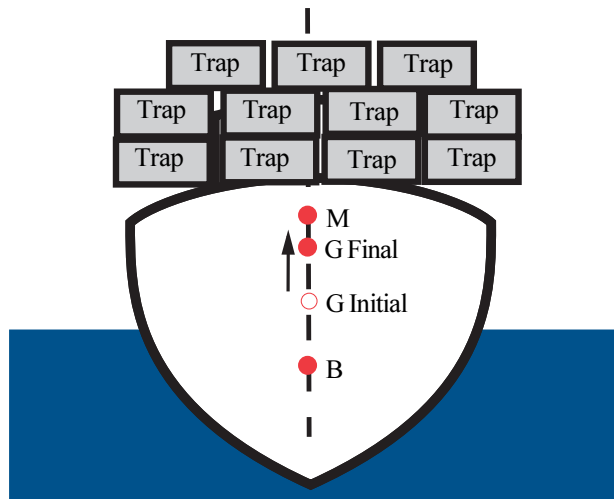
- ◆ Established when the vessel is built and initially outfitted for operation.
- ◆ When the vessel at rest possesses characteristics of the stable condition.
- ◆ Intact stability is considered to be adequate if GM is greater than or equal to two feet.
- ◆ Many older vessels are designed with GM between 1.6 and 2 feet. If your GM falls in this range it does not necessarily indicate your vessel is unsafe, but it would be well worth it to check with a marine architect.

Recommended Practice:

- √ Ensuring your vessel maintains adequate intact stability prior to getting underway will be a tremendous benefit when vessel is exposed to forces of fishing and the sea.
- √ Have your stability evaluated by a qualified individual.



IMPORTANT FACTORS THAT AFFECT VESSEL STABILITY



Factor: Load Height

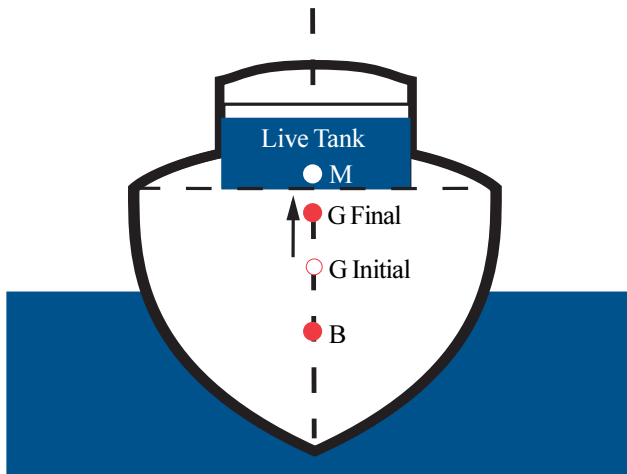
Problem: As the height of the stack increases, the vessel's center of gravity rises.

Affect on Stability:

- ◆ Reduces metacentric height significantly.
- ◆ The vessel moves out of the stable condition towards the unstable condition.

Recommended Practice:

√ Minimize the height of traps or pots on deck.



Factor: Live Tanks on Deck

Problem: The free surface effect generated by live tanks causes the vessel's center of gravity to rise.

Affect on Stability:

- ◆ Reduces metacentric height significantly.
- ◆ The vessel moves out of the stable condition towards the unstable condition.

Recommended Practice:

√ Minimizing the width and the number of live tanks.

IMPORTANT FACTORS THAT AFFECT VESSEL STABILITY

Factor: Suspended Weights - Act as though the entire weight is being added at the point of suspension.

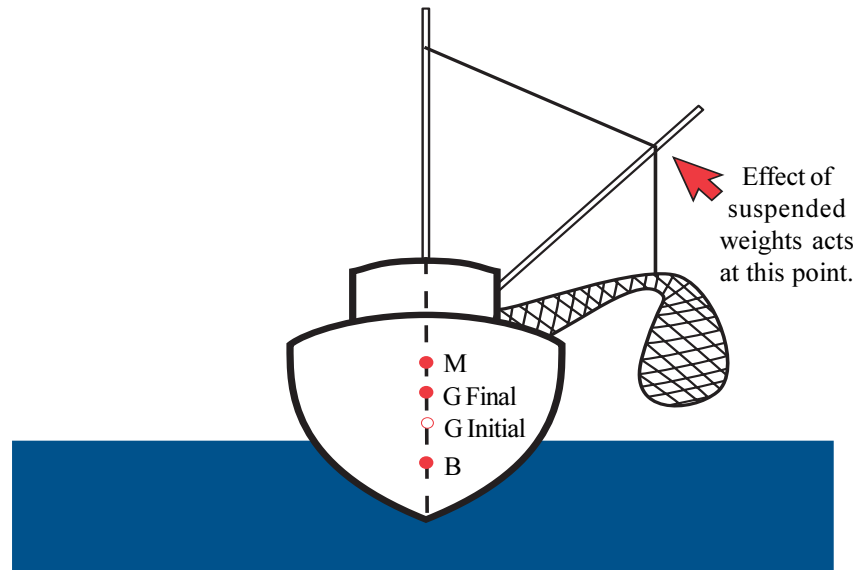
Problem: Causes a significant rise in the vessel's center of gravity. A capsizing force is developed.

Affect on Stability:

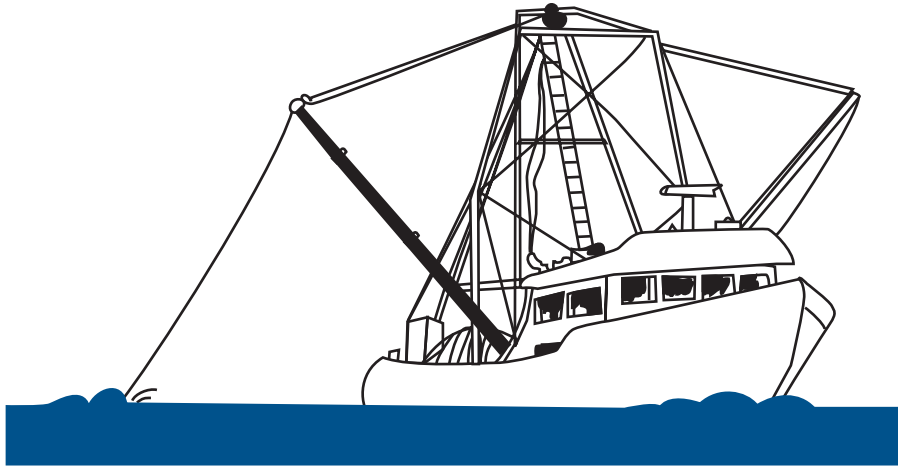
- ◆ Reduces metacentric height significantly.
- ◆ Vessel moves out of stable condition towards the unstable condition.

Recommended Practice:

- √ Minimize the duration of these operations.
- √ Exercise extreme caution when lifting over the side or quarters as change in center of gravity is even more significant.
- √ Ensure you prevent the suspended weight from swinging to mitigate adverse effects.



IMPORTANT FACTORS THAT AFFECT VESSEL STABILITY



Factor: High Tow Points - Have a significant affect on stability when towing off quarters or beams.

Problem: Significantly reduces GM. Vessel moves out of stable condition towards unstable condition. Similar to suspended weights.

Affect on Stability:

- ◆ The entire force of trawls, scallop/clam dredges, etc., acts at that point.
- ◆ This adds weight equal to that force at the tow point.
- ◆ Excessive capsizing forces are generated when towing off the quarter or beams.

Recommended Practice:

- √ After deployed, shift the towing point to a lower location.
- √ Maintain the tow on the longitudinal center line of the vessel (directly behind the vessel).
- √ Avoid towing off the quarter or beams.

DAMAGE CONTROL

Goal: Familiarize you with quick response procedures to mitigate flooding casualties.

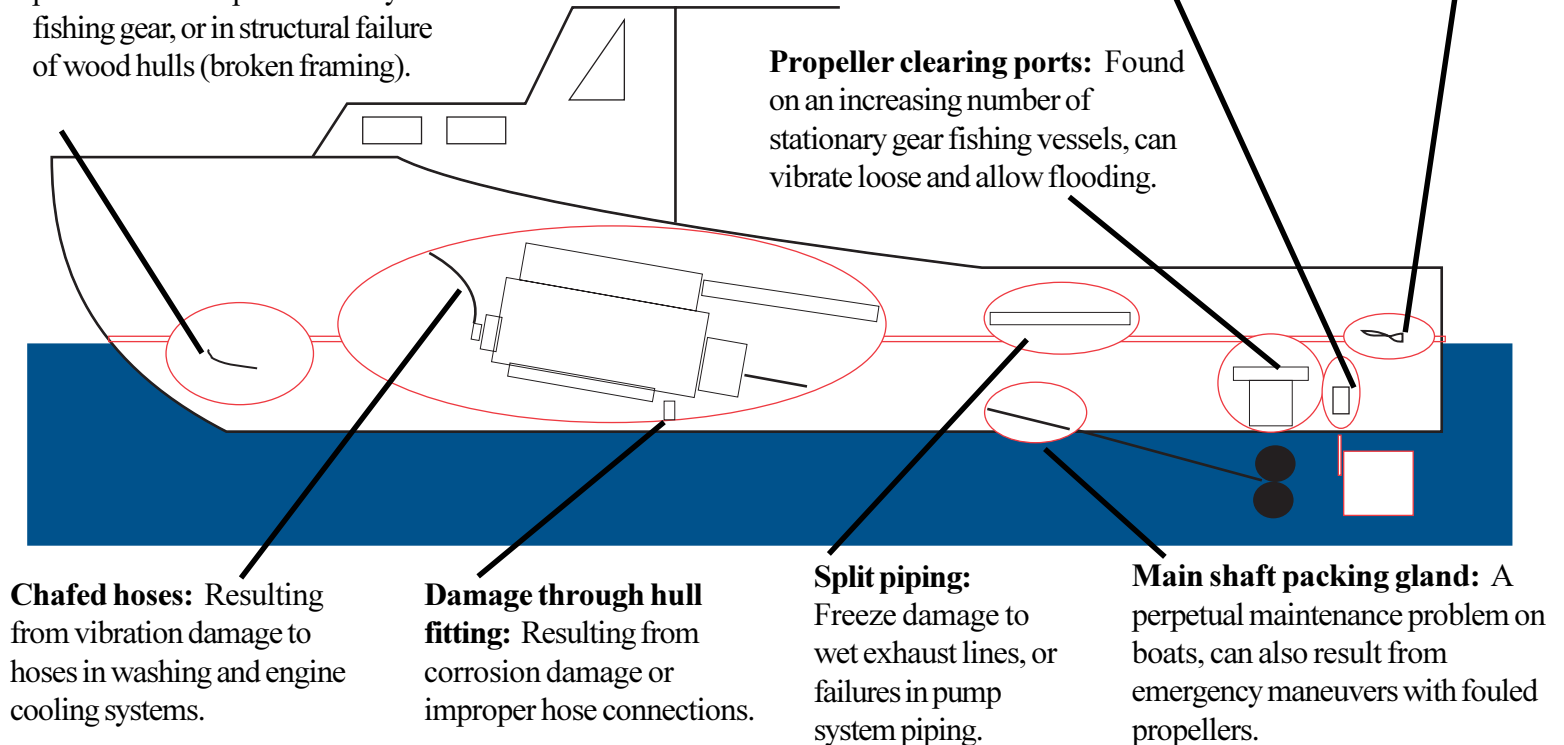
Common Small Fishing Vessel Flooding Scenarios

Small hull breach: Located here possibly from impact with floating debris such as logs. Also possible from impact of hull by fishing gear, or in structural failure of wood hulls (broken framing).

Damaged rudder port fittings: Packing problems with rudder posts results in many flooding cases. Structural failure (cracking) of the fitting housing has also been observed.

Large hull breach: Known to result from impact from fishing gear. Can also result from grounding and collision type accidents.

Propeller clearing ports: Found on an increasing number of stationary gear fishing vessels, can vibrate loose and allow flooding.



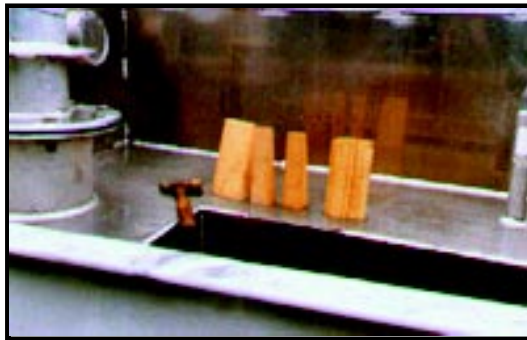
DAMAGE CONTROL



The Problem:

Small Hull Breach

Hull failure usually associated with impact with logs or other floating debris. May also be caused by structural failure of wood hulls.



The Tools:

Soft wooden wedges are used to plug cracks and other small hull breaches. Pine and fir are ideal for wedges because the wood is more likely to conform to the shape of the hull breach, is easy to handle, and will absorb water and swell, increasing the effectiveness of the plug.



The Solution:

Pound wedges into the breach with a hammer. Soft wood wedges are easy to split with a hatchet for filling small spaces. The wedges may be sawed off at the base to prevent inadvertent removal.

DAMAGE CONTROL

The Problem:

Chafed Hose

Vibrations can cause engine cooling hoses or water wash down hoses to wear and crack.



The Tools:

“Grease Tape” may be fashioned from 3 inch wide strips of burlap or landscaping fabric covered with industrial grade grease.



The Solution:

Wrap the “Grease Tape” tightly around a chafed hose.



DAMAGE CONTROL



The Problem:

Damaged Through Hull Fitting

Through hull fittings may flood a vessel because they are damaged by corrosion or because of improper hose connections.



The Tools:

Conical soft wood plugs are available from most marine suppliers. They should be sized according to the vessel's seacocks.



The Solution:

Pound the cone tightly into the open through hull fitting to stop the flooding.

DAMAGE CONTROL

The Problem:

Split Piping

Wet exhaust lines may split and cause flooding. This is usually associated with collision damage or freezing in extreme climate conditions.



The Tools:

A variety of fabrics may be used to cover large pipe cracks. Some of the best are pieces of discarded wet suits and foul weather gear fabric.



The Solution:

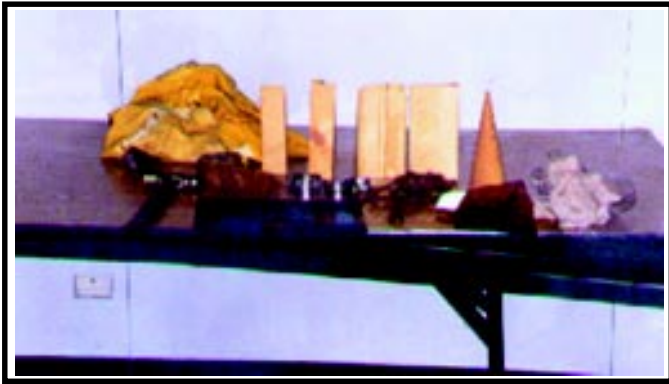
Place or wrap the material around the pipe. Tie tightly with cord.



DAMAGE CONTROL

Suggested materials and tools for small vessels

Damage control kits should be modified to reflect risks unique to a vessel or to a vessel's operating area. For example, wood hulled vessels might include pre-cut plywood sections and drywall screws to affect a rapid hull patch; vessels operating in cold waters should include neoprene gloves to limit cold water exposure concerns.



✓ **Conical soft plugs, sized as per a boat's seacocks**

✓ **Soft wood wedges**

✓ **“Grease Tape,” fashioned from burlap or landscaping membrane and covered in industrial grade grease.**

✓ **Manila twine**

✓ **Sheet rubber**

✓ **Simple hand tools, including:**

- Hatchet (for splitting wedges)
- hammer
- screwdriver
- C clamps
- small hand saw
- disposable flashlights

✓ **Spare hose clamps**

✓ **Water impervious patching material, such as sections of a discarded survival suit**

VESSEL CLEANLINESS

Goal: Maintain vessel in condition such that housekeeping is not the cause of vessel sinking. Keep bilges clean and free of debris.

Problem:

- ◆ Loose storage of traps, nets, & catch on or below deck could cause severe stability problems if allowed to shift while underway.
- ◆ Rags and floating debris can plug bilge pumps and damage machinery wiring, and eliminate dewatering capabilities.

Recommended Practice:

- √ Properly store catch and equipment below decks.
- √ Keep all suctions clear. Keep rags and debris properly stored.
- √ Properly install and protect wiring to bilge pumps and alarms.
- √ Keep it clean.



CREW TRAINING

Goal: Increase individual crew member expertise on handling emergency situations.

Drills and Instruction:

- a. The master or individual in charge of each vessel should ensure that drills are conducted and instruction is given to individuals on board at least once a month.
- b. Instruction should be provided in conjunction with drills or at other times and places provided it ensures that individuals are familiar with their duties and their responses to at least the following emergencies:
 - ◆ Abandoning the vessel
 - ◆ Fighting a fire in different locations on board the vessel
 - ◆ Recovering an individual from the water
 - ◆ Minimizing the affects of unintentional flooding
 - ◆ Launching survival craft and recovering lifeboats and rescue boats
 - ◆ Donning immersion suits and other wearable personal flotation devices
 - ◆ Donning a fireman's outfit and a self-contained breathing apparatus, if the vessel is so equipped
 - ◆ Making a voice radio distress call and using visual distress signals
 - ◆ Activating the general alarm
 - ◆ Reporting inoperative alarm systems and fire detection systems

CREW TRAINING

Participation in Drills:

Drills should be conducted on board the vessel as if there were an actual emergency and should include:

- a. Participation by all individuals on board.
- b. Breaking out and using emergency equipment.
- c. Donning protective clothing.
- d. Donning immersion suits.

Training:

Individuals conducting drills should have been trained in the proper procedures for conducting the activity.

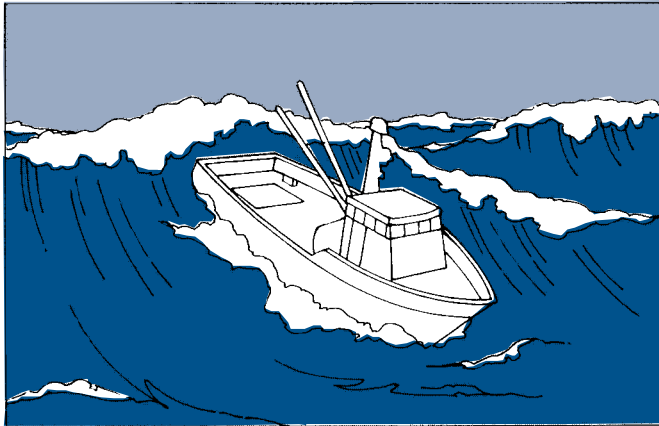
Safety Orientation:

- a. The master or individual in charge of a vessel should ensure that a safety orientation is given to every new individual aboard the vessel.
- b. The safety orientation should include:
 - ◆ Emergency instructions and cover the specific evolutions listed.
 - ◆ Basic maintenance of watertight integrity.
 - ◆ Methods to minimize free surface.

Training Documentation:

- a. Completion of monthly instruction, drills, and safety orientations should be logged in the vessel's log.
- b. Log entries should include the following:
 - ◆ Date and time of completion of each drill
 - ◆ Name of individuals administering the training
 - ◆ Name of individuals attending the training
 - ◆ Any lessons learned

PRUDENT SEAMANSHIP



Factor: Following Seas

Problem: Vessel's stability can be drastically reduced.

Affect on Stability:

- ◆ Increased chance of being swamped by a wave. Weight and free surface are added at an undesirable location. Center of Gravity rises. Stability is reduced.
- ◆ When perched on a wave, the vessel's ability to return to upright position is reduced when hull comes out of water. If overtaken by a wave crest, broaching may occur.

Recommended Practice:

- √ Change course.
- √ Reduce speed.

PRUDENT SEAMANSHIP

Factor: Beam Seas

Problem: Vessel's stability can be drastically reduced.

Affect on Stability:

- ◆ Excessive roll leading to cargo to shift could result in vessel capsize.
- ◆ Strong breaking waves could also capsize the vessel.

Factor: Quartering Seas

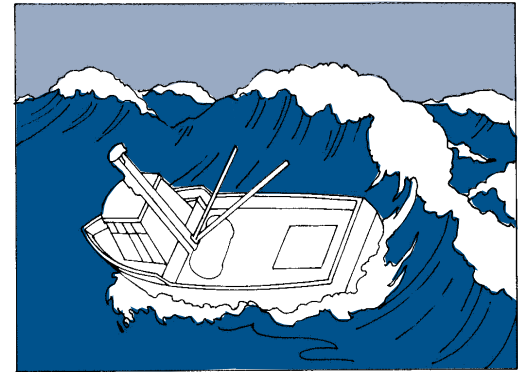
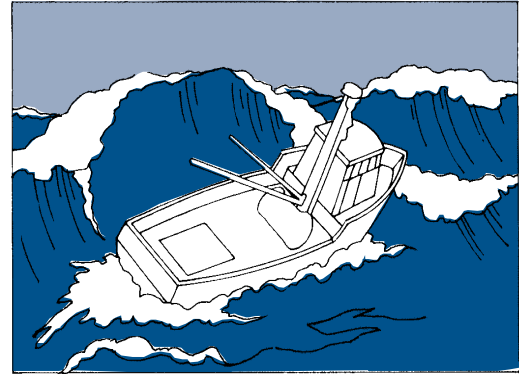
Problem: Quartering seas represent the most dangerous situation in severe weather. Vessel's stability can be drastically reduced. The problems of beam and following seas are combined.

Affect on Stability:

- ◆ Swamping or Perching could lead to capsize or broaching.
- ◆ Excessive roll leading to cargo to shift could result in vessel capsize.
- ◆ Strong breaking waves could also capsize the vessel.

Recommended Practice:

- √ Reduce speed, change heading, and steam into the seas.
- √ Dump deck load.



PRUDENT SEAMANSHIP

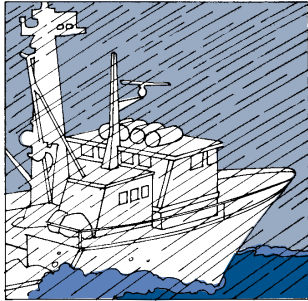


Factor: Icing

Problem: Significantly reduces GM. The Center of Gravity rises as weight is added to the superstructure.

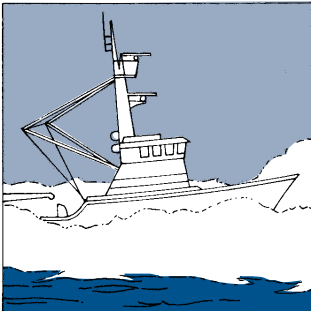
Affect on Stability:

- ◆ Icing increases the weight of the vessel and draft, reducing freeboard and consequently any reserve buoyancy.
- ◆ Icing raises the center of gravity of the vessel (G) causing a reduction in stability.
- ◆ Icing causes undesirable changes in trim and unwanted list.



Recommended Practice:

- √ Take the vessel to warmer or protected waters (Ice formation will be reduced when steaming down wind). Return to port if feasible.
- √ All fishing equipment on deck should be secured below decks. Derricks and like gear should be stowed in the lowered position.
- √ Freeing ports should be kept clear and watertight doors, manholes, and hatch covers should be battened down.
- √ All equipment for combatting ice formation should be ready for use.
- √ All emergency and lifesaving equipment should be ready for use. Radio communication with shore and other vessels should be maintained on regular basis.



RELATED STABILITY MATERIAL

Organization	Title
National Cargo Bureau	Stability for Fishermen
North Pacific Vessel Owner's Association	Vessel Safety Manual
National Council of Fishing Vessel Safety & Insurance	Gulf Coast Fishing Vessel Safety Manual
American Bureau of Shipping	Preparing Fishing Vessels' Stability Booklet
Canadian Coast Guard	Small Fishing Vessel Safety Manual
Transport Canada	An Introduction to Fishing Vessel Stability
National Research Council	Fishing Vessel Safety - Blueprint for National Program
International Maritime Organization	Code of Safety for Fishermen and Fishing Vessels, Parts A and B
	Torremolino Protocol - Safety of Fishing Vessels
United States Coast Guard	Voluntary Standards for Uninspected Commercial Fishing Vessels (NVIC 5-86)

Notes

Survive To Fish Another Day!

